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and black. The forehead is a velvety crimson running into black on the crown. Crimson appears also on the bend of the wings, on the under side of the wings intermingled with yellow, on the thighs and on some of the tail feathers; these tail feathers, exquisitely tinted with yellow at their extremities, are rounded and overlapped in a curiously beautiful fashion. All else the color is a predominating green, frequently flushed with red or grained with yellow. Bill and feet black, eyes yellow. The sexes are not easily distinguished.

ON A NEW CLASSIFICATION OF THE LEPIDOPTERA.

BY A. S. PACKARD.

The taxonomic importance of Walter's most interesting discovery that *Eriocephala calthella* has maxillæ constructed on the type of those of biting or mandibulate insects, *i. e.*, with an inner and outer lobe (lacinia) beside the palpi, was apparently overlooked by him as well as others, though its bearings on the phylogeny of the Lepidoptera as, however, insisted on by Walter, are, it seems to us, of the highest interest. The présence of the maxillary lobes, homologous with the galea and lacinia of the Mecoptera (Panorpidæ) and Neuroptera (Corydalus, Myrmeleon, as well as the lower orders Dermaptera, Orthoptera, Coleoptera, etc.), in what in other important respects also is the "lowest" or most primitive genus of Lepidoptera, the lacinia being a rudimentary, scarcely functional glossa or tongue, and not merely a vestigial structure, is of great significance from a phylogenetic point of view, besides affording a basis for a division of the Lepidoptera into two grand divisions or sub-orders, for which we would propose the names *Lepidoptera laciniata* and *Lepidoptera glossata*.

Sub-order I. LEPIDOPTERA LACINIATA.

Walter thus writes of the first pair of maxillæ: "The other mouth-parts also of the lower Micropteryginæ have a most

primitive characteristic. In the first pair of maxillæ of *Micropteryx calthella*, *aruncella*, *anderschella* and *aureatella*, cardo and stipes are present as two clearly separate pieces. The former in *M. calthella* and *aruncella* in comparison with the latter is larger than in *anderschella* and *aureatella*. In the last two species, the cardo is still tolerably broad, but reduced. The stipes are considerably longer than the cardo in the two last species, while it is of the same thickness. From the stipes arises the large 6-jointed palpus maxillaris, folded two or three times and concealing the entire front of the head and all the mouth-parts. *At its base, and this is unique among all the Lepidoptera, two entirely separate maxillary lobes arise from the stipes. The external represents the most primitive rudiment (anlage) of a lepidopterous tongue.*" (Fig. 1.) It is evident from Walter's figures and description that this is not a case of reduction by disuse of the tongue, but that it represents the primitive condition of this lobe or the galea of the maxilla, and this is confirmed by the presence of the lacinia, a lobe of the maxilla not known to exist in any other Lepidopterous insect, it being the two galeæ which become elongated, united and highly specialized to form the so-called tongue or glossa of all Lepidoptera above the Eriocephalidæ,¹ which we may regard as the types of the *Lepidoptera laciniata*.

Another most important feature correlated with this, and not known to exist in *Lepidoptera glossata* is the presence of two lobes of the second maxillæ, besides the 3-jointed labial palpi, and which correspond to the *mala exterior* and *mala interior* of the second maxillæ of Dermaptera, Orthoptera, Platyptera, Corrodentia, *i. e.*, Perlidæ, Termitidæ and Odonata, and also, as Walter states, to the ligula and paraglossæ of Hymenoptera. In this respect, the laciniate Lepidoptera are more generalized than Neuroptera, Trichoptera, or Mecoptera.

Walter thus describes the two lobes or outer and inner mala of the second maxilla: "Within and at the base of the labial palpi is a pair of chitinous leaves provided with stiff bristles,

¹ In his paper on the larva of Eriocephala, etc. (Trans. Ent. Soc. London, 1894, p. 335), Dr. Chapman separates the old genus Micropteryx into two families: *Eriocephalidæ* and *Micropterygidæ*. His group *Eriocephalidæ* I here regard as comprising the types of the sub-order *Lepidoptera laciniata* or *Protol Lepidoptera*.

being the external lobes of the underlip formed by the consolidation of the second pair of maxillæ, and which reach, when extended, to about the second-third of the length of the second palpal joint. Its inner edge is directly connected with the inner lobe (mala interna). The latter are coalesced into a short, wide tube, which, by the greater size of the hinder wall, opens externally on the point, also appearing as if, at the same time, cut off obliquely from within outwards.

"The outer anterior edge of the tube forms a strongly chitinous semi-circle which, becoming thinner, finally passes into the delicate membranous hinder wall. Also anteriorly a delicate membrane appears to cover the chitinous portion.

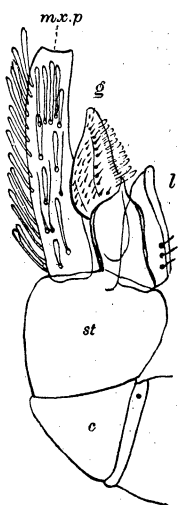


FIG. 1.

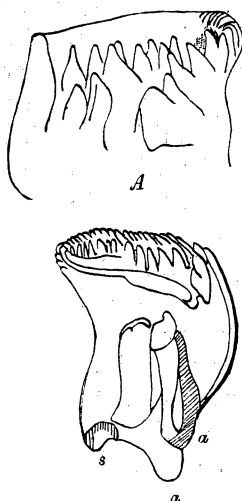


FIG. 2.

"We have here, in opposition to the weak, naked under lip represented by a triangular chitinous plate of the Lepidoptera, a true ligula formed by the coalescence of the inner lobes of the second maxillæ into a tube, as in many Hymenoptera, and with free external lobes, which correspond to the paraglossæ of Hymenoptera."

Walter has also detected a paired structure which he regards as the hypopharynx. As he states: "A portion of the inner surface of the tube-like ligula is covered by a furrow-like band

which extends close to the inner side, is coalesced with it and in position, shape, as well as its appendages or teeth on the edge may be regarded as nothing else than the hypopharynx."

While he refers to Burgess' discovery of a hypopharynx in *Danaïs archippus*, he remarks that this organ in the lower Micropteryginae (Eriocephalidæ) exhibits a great similarity to the relations observable in the lower insects, adding: "The furrow is here within coalesced with the inner side of the labium, and though I see in the entire structure of the head the inner edge of the ligula-tube extended under the epipharynx as far as the mandible; I must also accept the fact that here also the hypopharynx extends to the mouth-opening, as in all other sucking insects with a full-developed under lip, viz., the Diptera and Hymenoptera."

Another feature of importance, diagnostic of this suborder, is the mandible (Fig. 2), which, in form, size and the teeth are closely related to those of the lower mandibulate orders, being, as Walter states, in the form of true gnawing jaws, like those of the biting insects. They possess powerful chitinous teeth on the opposed cutting edges, 12 to 15 on each mandible, and also the typical articulating hook-like processes by which they are joined to the gena, and corresponding cavities are in the latter. In Micropteryx and other of the more generalized moths, the mandibles in a very reduced form here survive as functionless vestiges of the condition in Eriocephala.

Turning now to the head and trunk, we find other primitive characters correlated with those just mentioned.

The head is of moderate size, as wide as the body, with small compound eyes, and with two ocelli. The occipital region is well developed, as in the epicranium; the clypeus and labrum are of moderate size.

The generalized nature of the thorax is especially noteworthy. The prothorax is seen to be very much reduced, the two tergites being separate and minute, not readily seen from above. The rest of the thorax is very long, exhibiting but little concentration.

The mesothorax is but slightly larger than the metathorax, the mesoscutum is very short, the scutellum rather triangular than scutellate.

The metathorax is but little shorter and smaller than the mesothorax, and remarkable for the widely separated halves of the scutum, a Neuropterous character (compare *Ascalaphus* and *Corydalus*) in which it differs from *Micropteryx*. The slope of the scutellum is that of a low, flattened triangle.

As regards the abdomen, attention should be called to the disparity in size and shape between the sexes, also to the male genital armature, which is very large and completely exerted, and reminds us of that of *Corydalus*, in which, however, the lateral claspers are much reduced, and also that of certain *Trichoptera* (*Sericostoma*, *Tinodes*, *Stenophylax*, *Hydropsyche*, etc.).

The larval characters of this sub-order it would be difficult to give, for in the remarkable larva of *Eriocephala calthella* as described and figured in Dr. Chapman's elaborate account, we appear to have a highly modified form, entirely unlike the simple apodous larva of *Micropteryx*, and perhaps quite unlike the primitive stem-form of *Lepidopterous* larvæ. We are indebted to Dr. Chapman for mounted specimens in a slide kindly given us by him. The body is broad and flattened, the segments very short in proportion to their width, the prothoracic segment, however, very long in proportion to the others, but the surface rough and corrugated, not with a hard, smooth dorsal plate as in many *Tinidæ*, *Tortricidæ*, etc., since it is not a boring insect. The eight pairs of abdominal prop-like tubercles, which we should hardly regard as homologues of the abdominal legs, are, like those of the *Panorpidæ*, simple tubercles armed with a curved spine. The tenth or last abdominal segment is armed with a pair of dorsal spines, arising from a tubercle. The singular flattened and fluted setæ represented by Chapman are unique in *Lepidopterous* larvæ. He also describes a trefoil-shaped sucker on the under side of the ninth and tenth abdominal segments, "very unusual;" though as it appears to be paired, it does not, as Chapman thinks, seem to us to indicate "a further point of relationship to *Limacodids*."

Chapman states that "the head is retractile, so far, that it may occupy the interior of the second thoracic segment," and he says that "the antennæ are remarkably long for a

Lepidopterous larva." He remarks that there are "two strong mandibles, with four brown teeth," and adds: "two pairs of palpi are also visible—two- and three-jointed, apparently those usual in Lepidopterous larvæ, but I have not defined their relations. There is also a central point (spinneret?)"

I add rough sketches of the mouth parts, so far as I could draw them with the camera from specimens mounted in balsam by Dr. Chapman. The labrum (Fig. 3, *lbr.*) is less divided than usual in Lepidopterous larvæ, but is not, in this respect, much unlike that of Tineids *e.g.* *Gracilaria* (see Dimmock's Fig. 2, p. 100, *Psyche*, iii). The four-jointed antennæ (Fig. 3A *ant.*), ending in two unequal setæ, are of very unusual

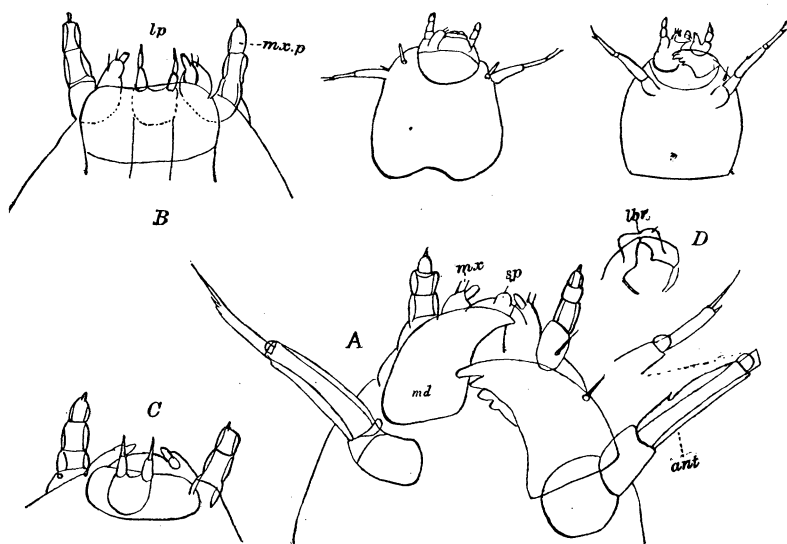


FIG. 3.

size and length, and so are the maxillary palpi (Fig. 3B *mx.p.*) which are much larger than in any caterpillar known to me, and greatly in disproportion to the maxillary lobes; the maxillary itself differs notably from that of other caterpillars; what appears to be the lacinia is palpiform and two-jointed. The labium and its palpi are much as in *Gracilaria*, but appear to be three-jointed, with a terminal bristle (it is possible that there are but two joints). Unlike the larva of *Micro-*

pteryx, that of *Eriocephala* does not appear to possess a well-marked spinneret; while it is easy to see it in the former genus, in *Eriocephala* I can only detect a lobe which appears to be simply the rudiment (*anlage*) of a spinneret (unless the latter is in my specimen bent under the head); but this organ needs further examination on fresh specimens. It would be interesting if it should be found that the spinneret is in a generalized or germinal condition, as compared with that of *Micropteryx*.

The pupa.—Unfortunately, we are, as yet, ignorant of the pupa form. Dr. Chapman has only found the head-piece of the pupa, but refers it to the “*Incompletæ*,” and thinks it probable that the pupa has the “third and following abominal segments free”

The eggs.—The egg, according to Chapman, is “large and spherical,” and laid in confinement in little groups, to the number of twenty-five in all.

Diagnostic characters of the Lepidoptera laciniata.—I add the characters of this sub-order. Imago. Maxilla with a well-developed lacinita and galea, arising as in mandibulate insects from a definite stipes and cardo, the galea not elongated, united and differentiated into a glossa, each galea being separate from its fellow, and the two not acting as a “tongue.” The maxillary palpi enormous, six-jointed. Mandibles large, scarcely vestigial, with a broad, toothed cutting-edge, and with them apparently functional hinge-processes at the base, as usual in mandibulate insects. Hypopharynx well-developed, somewhat as in Diptera and Hymenoptera; second maxilla divided into a mala exterior, and a mala interior, recalling those of mandibulate insects; palpi three-jointed. Thorax and prothorax very much reduced; metathorax very large, with the two halves of the scutum widely separate.

Venation highly generalized; both fore and hind wings with external lobe or a “jugum” as in Trichoptera, veins as in *Micropteryx* and showing no notable distinctions compared with those of *Micropteryx*; scales generalized; fine scattered setæ present on costal edge and on the veins. Abdomen elongate, with the male genital armature neuropteroid, exserted, the dorsal, lateral and sternal appendages very large.

Eggs spherical. Larva, in form, highly modified, compared with that of *Micropteryx*, with large, four-jointed antennæ and very large three-jointed maxillary palpi; no spinneret? No abdominal legs, their place supplied by a pair of tubercles ending in a curved spine on segments 1-8; a sternal sucker at the end of the body. Pupa libera?

*Sub-order II. LEPIDOPTERA HAUSTELLATA.*²

This group may be defined thus: Maxillæ with no lacinia, the galeæ being highly specialized and united with each other to form a true tubular haustellum or glossa, coiled up between the labial palpi. The maxillary palpi large and fine or six-jointed in the more generalized forms, usually vestigial or entirely wanting in the more modern specialized families. Mandibles absent, as a rule, only minute vestiges occurring in the more generalized forms. Wings both jugate and frenulate, but mostly the latter, tending to become broad and with highly specialized scales, often ornamented with spots as well as bars, the colors and ornamentation often highly specialized; the thorax highly concentrated, the metathorax becoming more and more reduced and fused with the mesothorax; the abdomen in the generalized forms elongated, and with large exerted male genital armature.

Pupa incomplete, the abdominal segments 3 to 6 or 7 free, in the more generalized primitive forms, the end of the maxillary palpi forming a visible sub-ocular piece or "eye collar;" or a flap-like piece on the outside of the maxillæ; the labial palpi often visible; clypeus and labrum distinct; paraclypeal pieces distinct; no cremaster or only a rudimentary one in the generalized primitive forms.

Larva with usually a prothoracic or dorsal chitinous plate; the armature consisting, in the primitive forms, of minute one-haired tubercles, the four dorsal ones in a trapezoid on abdominal segments 1-8, becoming specialized in various ways in the later families into fleshy tubercles, or spines of various shapes. Five pairs of abdominal legs, with hooklets or crochets forming

² If the term *haustellata* should be thought inapplicable from its frequent use by former authors, the term *Lepidoptera glossata* could be used instead.

a complete circle in the more generalized forms (in Hepialidæ several complete circles), the hooklets in the latter more specialized groups, usually forming a semicircle situated on the inner side of the planta.

This sub-order may be sub-divided into two series of superfamilies and families, the *Paleolepidoptera* and the *Neolepidoptera*.

I. PALEOLEPIDOPTERA (*Pupæ liberæ*).

The characters of this group are those of Micropteryx, whose larva has a well-developed spinneret; though it has no abdominal legs, the other features are so truly lepidopterous that the absence of legs may be the result of reduction by disease, rather than a primitive feature.

The pupa (Fig. 4) has entirely free antennæ, mouth-parts and limbs, and bears considerable resemblance to that of a caddis-fly. The mandibles are enormous, and, as described by Chapman, are adapted for cutting through the dense cocoon. The maxillæ are separate and curved up on each side and partly concealed by the labial palpi, not extending straight down as in the *Pupæ incompletæ* and *obtectæ*; the maxillary palpi situated just in front of the mandibles extend outward and forward, reaching to the antennæ. The labrum is deeply cleft and strongly setose, as is the epicranium; the clypeus is square, with a singular, white, delicate membrane, the use of which is unknown. The hind legs extend beyond the end of the abdomen, which is simple, not terminating in a cremaster; the sides of the segments bear a single large seta.

The trunk characters are much as in Eriocephala. The head is larger and squarer, the eyes very small; there are two ocelli present; the clypeus and labrum short and small.

The prothorax is very much reduced, much as in Eriocephala; the metathoracic scuta show an advance over those of Eriocephala in being united on the median line instead of separated; the metoscutellum is very large, larger and more scutellate than that of Eriocephala.

The shape and venation of the wings (Fig. 5) are nearly identical with those of Eriocephala, being long, narrow and

pointed, both pairs nearly alike in size and venation, except that on the hinder pair there is a "jugum" or angular fold: scales are of generalized shape all over the wing. The pres-

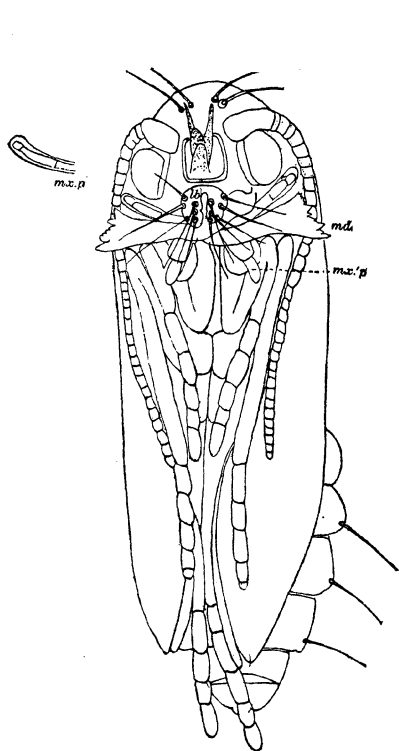


FIG. 4.

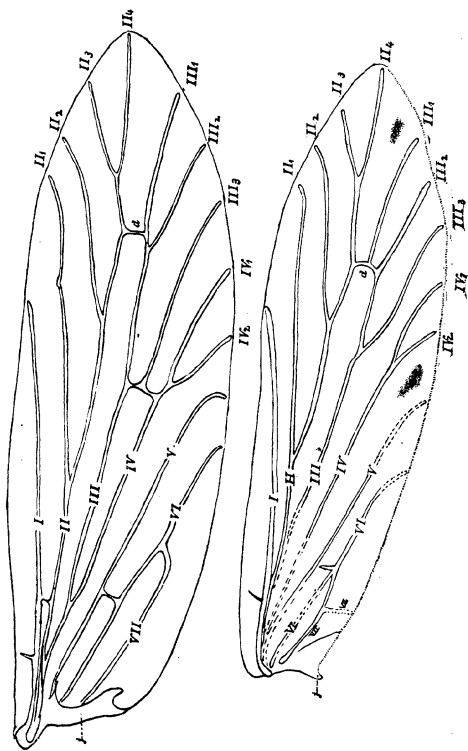


FIG. 5.

ence of a jugum on both pairs of wings is significant, since in Trichoptera, they are also present in both pairs of wings.

II. NEOLEPIDOPTERA.

This series may be divided into two sections, corresponding in the main to the *Pupæ incompletæ* of Chapman (the Eriocephalidæ and Micropterygidæ included by Chapman being removed), and his *Pupæ obtectæ*, for the first of which we would suggest the name *Tineoids*, and for the second, the large broad-winged forms or Macrolepidoptera or Platylepidoptera.

Tineoids or *Stenopterygia*.

These are Tineoid forms with many vestiges of archaic features, usually with narrow wings, of dull hues or with metallic bars, or with highly specialized shapes of scales and spots, and the venation generalized in the earlier forms. The maxillæ are sometimes aborted (wholly so in *Hepialidæ*); maxillary palpi either well-developed, more or less reduced, or wanting; mandibles rarely occurring as minute vestiges; the thorax neuropteroid in the more primitive forms becoming shorter and the segments fused together in the later or more specialized groups.

The pupæ are incomplete; the more primitive forms with the eye-collar and labial palpi visible; paraclypeal pieces distinct; abdomen often with no cremaster in the most primitive forms.

Larvæ with one-haired tubercles, the four dorsal ones arranged in a trapezoid on abdominal segments 1-8; usually a prothoracic dorsal plate; the abdominal legs sometimes wanting in certain mining forms (and *Cochliopodidæ*); larvæ often case-bearers or borers; crochets on the abdominal legs in the primitive types arranged in two or more complete circles; in the lowest forms a well-marked spinneret.

Remarks on the Tineina.—It must now be very obvious that we need to re-examine and revise the Tineina, and especially their pupæ and imagines, particularly those of the more generalized forms, such as the Tineidæ (*Tinea* and *Blabophanes*), and the Talæporidæ, comprising all those ancestral forms with broad wings and a generalized venation which may have given rise to the neolepidopterous families.

Then careful studies should be made on the Adelidæ, Choreutidæ and Nepticulidæ, and other families and genera in which the mandibles have persisted (though in a vestigial condition), and also those with functional or vestigial maxillary palpi, such as Tineidæ, Gracilariidæ, Elachistidæ, etc.

It is evident that the classification of the Tineina will have to be entirely recast; instead of placing the Tineidæ, with their broad wings and generalized venation at the head of the Tineina as done in our catalogues and general works, they should go to the base of the series, not far from the Microptery-

gidæ. On looking over the venation of the Tineidæ represented on Spuler's Plate XXVI, it is evident that the very narrow-winged genera, such as *Coleophora*, *Ornix*, *Lithocolletis*, *Nepticula*, *Gelechia*, *Cemiostoma* and *Æcophora*, are highly modified recent forms, when compared with *Tinea* and *Blabophanes* as well as the Adelidæ (*Adela*, *Nemotois*, *Choreutidæ*, *Simaethis* and *Choreutis*) and justify Chapman in associating them with the Pyraloids in his group of *Pupæ obtectæ*.

Family *Prodoxidæ*.—This group is represented by *Tegeticula* (*Pronuba*) and *Prodoxus*. The eye-collar (maxillary palpi, Fig. 6, *mx p*) is larger than in any of the other Tineina, and

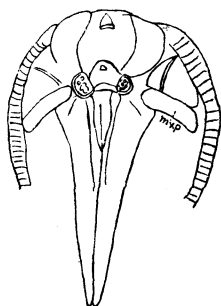


FIG. 6.

the group is thus intermediate between the Neo- and Paleolepidoptera. The pupa, as well as other stages, have been well-described by Riley, who, however, has overlooked the eye-collar, though he figures and describes the remarkable "maxillary tentacles." I am disposed to regard the latter organ as the maxilla itself, and to consider that the "maxilla" of Riley is the lacinia or inner lobe of the maxilla, but

have had no material for examination. Should this prove to be the case, it would carry the family down among the *Lepidoptera laciniata*.

(To be continued.)

RECENT LITERATURE.

Some Recent Text-books and Student Guides.—For several years the crying need of American teachers has been a text-book of zoology which, in contents and manner of treatment, should be of use in American colleges and technical schools. All that our publishers had offered us were books which were far behind the times, and some were far behind any times unless we go back to that long ago when